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Delivering a decision support system tool to a river contract: a way to implement the participatory approach principle at the catchment scale?

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Abstract

The MULINO project (MULti-sectoral, Integrated and Operational decision support system (DSS) for sustainable use of water resources at the catchment scale), funded by the Environment and Climate Programme of the European Union (EU), aims to support the scientific basis for integrated water management. The purpose of the project is to provide a tool to improve the integrated management of water resources at the catchment scale, based on the requirements of the EU Water Framework Directive (WFD).

This paper presents the methodology aspects of the project. The design of the MULINO_DSS is based on the European Environment Agency DPSIR framework of environmental cause-effect relationships. *D* represents the driving forces, *P*, the pressures on the environment caused by human activities, *S*, the state of the environment, *I*, the impact on the environment and *R*, the human activities and desirable societal responses. This DPSIR chain provides the end-user of the DSS with an integrated view of complex, interacting issues.

The first step in the MULINO project has been the analysis of local decision networks and the identification of an end-user to whom the DSS will be delivered. The importance of this step is illustrated by the results of the analysis for the Belgian case study: the Walloon part of the Dyle river catchment. The design of the DSS is made more complicated in this catchment by the fragmented nature of water management decision making. However, to overcome this problem, the design of the DSS was targeted at the river contract (RC) of the catchment. The coordinator of the RC is a focal point for a range of end-users and stakeholders with responsibility for water management in this catchment. This organisational structure was originally put in place to find a consensus when solving conflicting water management issues. Thus, the concept for the DSS development and delivery fits with the participatory approach principle of the WFD and builds on existing local networks of integrated water management.

Keywords: Decision support system; Participatory approach; Water framework directive; River contract; MULINO European Union project

1. Introduction

The pressure on water resources is continuously increasing in Europe, and managing water resources in a sustainable way is a challenging task. In recent years, many research efforts have focused on the solution of specific problems for the management of water resources. A great deal of scientific knowledge is now available in many sectors, but this knowledge is often treated in isolation.

The MULINO project (MULti-sectoral, Integrated and Operational decision support system for sustainable use of water resources at the catchment scale), which is funded by the Environment and Climate Programme of the European Union (EU), is being undertaken to support the scientific basis for integrated water management. The purpose of the project is to provide a tool to improve the integrated management of water resources at the catchment scale, following the requirements of the EU Water Framework Directive (WFD, J.O.CE, 2000). The main objectives of the MULINO project are to (1) make a multidisciplinary diagnosis of the main issues for local water management, (2) conceptualise an operational

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Decision Support System (DSS) for integrated water management, (3) define a set of water management alternatives, and (4) test a set of future scenarios of environmental change.

Many countries have had delays when implementing water-related Directives in the past (Aubin and Varone, 2002), which is often a result of the decision context of the management of water resources at the national or at more local scales. Thus, a clear understanding of how the national and local decision context works is needed before starting to develop a DSS for local water managers.

In this paper, we first present the MULINO methodology at the European scale. Secondly, we focus on a particular case study—the Dyle catchment situated in central Belgium—by describing the main characteristics of its decisional context. Then we discuss why delivering a DSS tool to the coordinator of the river contract (RC) of the Walloon part of the Dyle catchment is original and suitable for the integration of the management of water resources at the catchment scale. By original we mean that existing local networks of integrated water management are used. By suitable, we mean that the methodology fits with the participatory approach principle required by the WFD to provide sustainable management of water resources in Europe.

2. Methodology for the development of the MULINO_DSS software

DSS are computer tools that are used to support problem solving and decision making (Shim et al., 2002). The MULINO_DSS aims at organizing and communicating indicators that could be used to assist sustainable decisions by integrating environmental, economic and social information. The DSS is a software package based on hydrological modelling, multi-disciplinary indicators and multicriteria evaluation procedures. Two scales are studied: the catchment scale and the European scale as the DSS will be implemented in six catchments of five European countries: Belgium, Italy, Portugal, Romania and the United Kingdom. Geographical Information System (GIS)-based hydrological models, run with interfaces within the DSS tool, support testing of the impact on water resources of different management alternatives. Capabilities for geographical data handling and display are embedded within the DSS to support the management of spatial data and the interface with the user.

2.1. DPSIR

The European Environment Agency uses a chain of linkages defining cause and effect relationships between the driving forces within society (*D*), the pressures on the environment caused by human activities (*P*), the state of the environment (*S*), the impact on the environment and on human activities (*I*) and desirable societal responses (*R*) to these impacts (OECD, 1993; EEA, 1999). The links within the DPSIR chain are described by indicators which have two main functions (1) reducing the number of parameters and (2) simplifying the communication process by which information and results are provided to the user. An indicator is a parameter or value derived from a parameter which provides information about a relationship between the DPSIR chain elements. As indicators are used for varying purposes, it is necessary to define general criteria for indicators at each stage of the DSPIR chain. The indicators should have (1) user and policy relevance, (2) an analytical soundness, and (3) measurability (OECD, 1993). This framework provides the decision maker with an integrated view of environmental issues.

As modelling seems to be the only way to integrate the available scientific knowledge and data deliver adequate information for policy preparation (Luiten, 1999), the MULINO_DSS links the DPSIR framework to hydrological models (Fig. 1). In the MULINO_DSS, the management alternatives represent the possible responses (*R*) proposed to address the impacts (*I*). These are termed « options » and represent the feasible actions or activities to solve a decision problem.

To explain the structure of the MULINO_DSS within the DSPIR cause-effect relationships, consider an example of a DPSIR chain constructed for the flooding issue in the Dyle catchment. The driving force (*D*) is the climate. The pressure is the rainfall. The state (*S*) is the height of surface waters which leads to flooding when a defined threshold is surpassed. The impact (*I*)-considered only if it is negative for the environment and/or human activities-is a function of where and when the flooding takes place (e.g., the impact of flooding is more important in cities than in wetlands and varies in agricultural areas during the year as a function of the crop growing). To reduce the impact of flooding, the management options (*R*) could be, for example, to (i) build a storm basin, (ii) restore river banks, (iii) dredge the river or (iv) rehabilitate wetlands. The hydrological models linked to the DSS provide values for criteria selected by the end-user (e.g. flow in the river, volume stored in the storm basin and so on...) for these four options.

It is also possible to test some scenarios by choosing different values for the driving forces (*D*). In the flooding example, forecasts of climate changes (as a driving force (*D*)) would have consequences on the amounts of rainfalls (pressures, (*P*)) thus with changes on the values of (*S*) and (*I*) indicators.

2.2. Multicriteria analysis

Multicriteria analysis (MCA) is a set of methods for supporting the choice among alternatives. These meth-

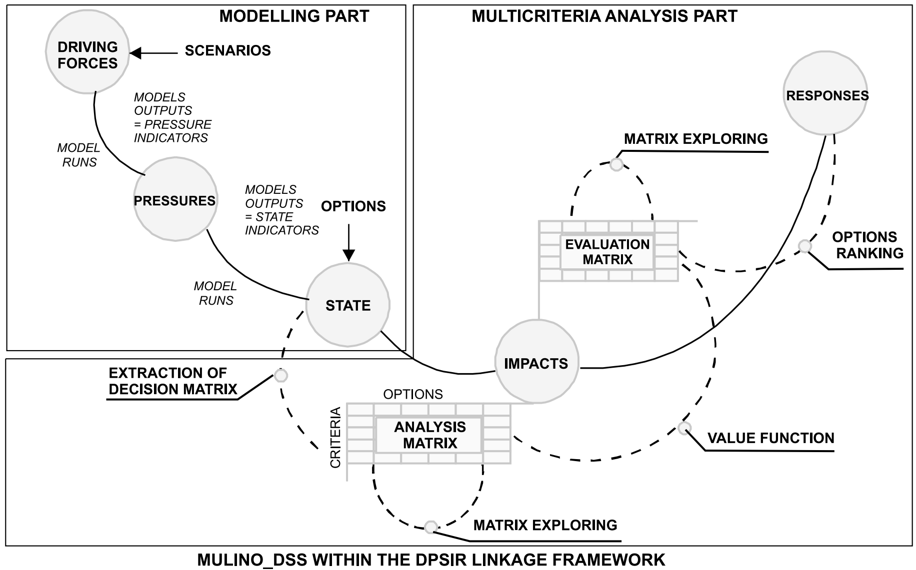

Fig. 1. The structure of the MULINO_DSS.

ods are widely used in operational research and decision making as a background to Multicriteria Decision Support Systems (Siskos and Spyridakos, 1999). The output of the decision-matrix is a value score provided by a value function. A value function is a mathematical representation of human judgements which permits the translation of the performance of the alternatives into a value score, which represents the degree to which a decision objective is met.

During the decision process, the whole DPSIR cause-effect chain should be constructed, but in the last decision phase (the choice between the options), the *S–I–R* sub-chain is involved. The indicators of state (*S*) from the model runs are compiled in a GIS attribute table. The values of the criteria of the indicators are extracted to fill a matrix with the options in the columns and the criteria in the rows (Fig. 1 point 1.). To be comparable, values are transformed (normalisation, Fig. 1 point 2.). Then the end-user must give a weight (Fig. 1 point 3.) to each criteria by attributing a value following the proposed procedure within the DSS. The multiplication of the value of criteria by their weights gives the final value of each criteria. The sum of the final value of all the criteria for each option is the assessed value of the option. The options are then ranked following this final value contained between 0 and 1 (Fig. 1 point 4.). The option with the highest value is the one that is most appropriate for ameliorating the impact considering the importance of all criteria.

2.3. Hydrological modelling

The role of simulation models in the MULINO_DSS is to allow a sound translation of R/P variables into relevant catchment *S* variables and indicators (Fig. 1). As explained above, the models give values of indicators of both options and scenarios. As the MULINO project focuses on sustainable uses of water resources at the catchment scale, hydrological modelling plays a key role, but land use change models can also be used in particular for scenario implementation. Each case study in MULINO uses a hydrological model that is most appropriate for the characteristics of the catchment. The models are validated with available data.

2.4. Identification of end-users of the MULINO_DSS

Relationships between social actors are structured in the form of networks that tie individuals together (Degenne and Forsé, 1994). « *Delineation of the social and organisational networks by the scale at which they operate provides a framework within which to examine the potential for integrated and inclusive resource management* » (Tompkins et al., 2002, p. 1108). Thus, in our aim to develop a tool to support integrated management of water resources at the catchment scale (« local »), it is important to (i) identify the decision tree of the management of water resources within the catchment by studying the institutional regimes, (ii) understand the relationships between the different groups of actors on water resources by studying the local networks, (iii) to identify a suitable user of the MULINO_DSS by exchanging information with the local networks. Continuous and regular exchanges with the local networks are important for the construction and implementation of the MULINO_DSS since these networks are dynamic evolving through time.

3. The case study: the Dyle catchment in Wallonia (Belgium)

The part of the Dyle catchment in Wallonia is 650 km^2 and situated in central Belgium (50°38′ N, 4°45′ E) as part of the Scheldt basin. At its outlet from Wallonia, the mean discharge is about 4.5 m^3/s. The catchment has a population of 200,000 in 17 communes, with a population density of 310 inhabitants/km^2. The domestic effluent of 150,000 inhabitants are currently treated. According to the classification for the nitrates directive, the catchment is situated in the vulnerable zone of the Brussels sands. There are two valleys which are protection zones for European birds. The land use comprises 50% arable land, 22% built-up areas, 9% pastures and 19% non-built-up areas with forests and wetlands.

In general, flooding and high levels of nitrates and pesticides in both surface and groundwater are the main pressures on the water resources.

4. The decisional context for water resources management in the Belgian case study

4.1. Introduction

Legislation concerning water resources was the first theme tackled by the environmental politics of the EU in the 1970's. Presently, some 25 European directives address water issues. Because of the amount of legislation concerning water resources, a new, more coordinated legislation was requested by the EU Parliament and the Council (Aubin and Varone, 2002). Thus, during the last 10 years, water policies in the EU were revised, leading to the Water Framework Directive (WFD) and the cancellation of some of the 25 directives. The WFD represents a new step in EU policy regarding water resources by combining previous policies into a common policy (Aubin and Varone, 2002). This new directive is more ambitious than all previous directives on the management of water resources.

The study of the development of the implementation of previous EU water directives can help in the appraisal of possible difficulties in the implementation of the WFD. Belgium, for example, was one of the European countries that experienced major delays in the implementation of previous directives. Belgium has only just implemented the nitrates directive and its first waste water treatment plant in Brussels (2001). An historical analysis of the institutional water regimes in Belgium (Aubin and Varone, 2001) partly explains these delays. A study of the national and local decision context gives a better understanding of the potential for the integration of the management of water resources at the catchment scale.

4.2. The decentralisation of the Belgian water policy

Water management in Belgium is fragmented at different administrative levels. Belgium has been a Federal State since 1993. Regions and Communities were added to the existing administration levels of 10 Provinces and 589 communes. The Regions have been responsible for environmental issues, including water management since the 1980s. There are three governments for the three regions of Brussels Capital, Wallonia and Flanders, which have their own responsibility for both surface and groundwater management. The attribution to the Regions of the management of navigable streams came later, in 1990. In Wallonia, this led to the creation of the « Ministère de l'Equipement et des Transports ». The EU Directives concerning water resources are translated into law in each Region. The 1980s and the beginning of the 1990s were periods of huge adaptation for regionalised Belgium. The process of regionalisation delayed the translation and implementation of the 1970s and 1980s European Directives concerning water resources (Aubin and Varone, 2001).

Water management in each Region is now completely different. The parts of the Dyle catchment in Wallonia and the parts in Flanders can be considered as two different case studies. Because of this, it was not possible for the MULINO project to work on the whole of the Dyle catchment in developing the DSS. The study deals therefore with water management in Wallonia only.

4.3. Water authorities in Wallonia

The DGRNE (Direction Générale des Ressources Naturelles et de l'Environnement/General Directory for Natural Resources and the Environment) of the Ministry of the Walloon Region has a water division (Division de l'Eau) that is responsible for the coordination of the implementation of water resource management in Wallonia, both with respect to surface and groundwater. This division comprises seven departments (surface waters, non-navigable waters, groundwater, sewage treatment, water uses taxes, soil protection, high volume production and transport). Each division has the responsibility for one aspect of the management of water resources within the water cycle. The main objective is the quality concern of both surface and groundwater. Unfortunately, water management plans do not yet exist and the relationships between services, when they exist are, therefore, informal.

Within the DGRNE, the maintenance of non-navigable streams depends on the catchment area of the streams (Table 1, decree 28.12.1967 for non-navigable streams). For the non-classified non-navigable streams, the owners can be the communes or private owners.

Table 1
Water authority of non-navigables streams in Wallonia (Belgium)

Area of the catchment of the navigable stream	Category of the stream	Water authority
⩾5000 ha	1st	Region
Not classified in the 1st or in the 3rd category	2nd	Province
⩾100 ha and until the end of the commune	3rd	Commune
<100 ha	Not classified	Owners

4.4. Coordination of water uses in Wallonia

In Wallonia, a public society for water management (SPGE, Société Publique de Gestion de l'Eau) was created in 1999 (by decree M.B. 22.06.1999) to coordinate the financial aspects of « *human* » water use. The SPGE collects funds to improve the distribution of drinking water and is responsible for the coordination and management of the distribution of drinking water and the collection and treatment of domestic waste. It also manages the protection of sites for the extraction of drinking water. At present, there are no completely private institutions that manage water resources in Wallonia (Aubin and Varone, 2001).

At the local scale, the exploitation of water resources for drinking and distribution is the concern of groups of communes (compagnies intercommunales). In the Dyle catchment, it is l'Intercommunale du Brabant Wallon (IBW). The Intercommunales are organised within the SWDE (Société Wallonne de Distribution des Eaux). A « contrat de service » is established between the SPGE and all the exploitation groups (Fig. 2).

4.5. The river contract in Wallonia

The idea of launching a RC in Wallonia was influenced by (1) specific issues related to water management in the country, (2) the environmental agenda defined at the Summit of Rio in 1992 and in particular the policy agenda for sustainable development, and (3) the existence of the French reference model of RCs. A RC is an agreement between the largest possible number of water actors from both the public and the private sector. It aims at harmonising the diverse uses and functions of the river, its banks and the water resources of the catchment. It encourages the implementation of actions for river management, described in an action plan that derives from the consensus of all the actors listed in the RC agreement. The programme of actions aims to restore, protect and enhance the value of water resources while considering all the characteristics and functions of the river. It also has the role of raising public awareness of sustainable development activities within the catchment.

The first institutional definition of the RC in Belgium came with the declaration of the regional policy on 22/01/1992. A « circulaire ministérielle » (18/03/1993) of the Ministry of the environment and management of the territory specified the modalities of the development of a river contract in Wallonia. A circular in 2001 from the Ministry of agriculture and rural affairs extended the time period for the implementation of the RC from 4 years to 4 years twice renewable.

A RC is developed in five phases. (1) The initialisation comes from actors (public as well as private) who

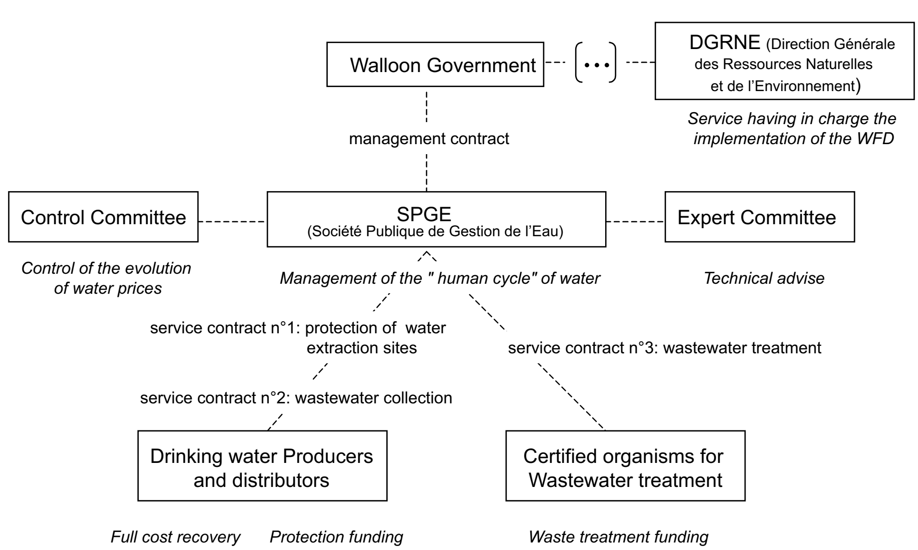

Fig. 2. The institutional position of the Public Water Management Society in Wallonia (Belgium).

express the wish to create a RC around specific issues. The first programme of actions attributed to the first actors is submitted to the Ministry. (2) The Ministry gives its agreement to the project, defines the coordinator and details the mission. (3) The coordination has to involve the maximum number of actors in the project. A consensus has to be found on a programme of actions based on a detailed inventory of the state of the water resources and the main issues in the catchment. When consensus is found with a task for concerned actors, the draft contract is signed. This date marks the beginning of the RC. (4) The programme of actions is implemented. (5) After 4, 8 or 12 years, the programme of actions is revised.

4.6. Why work with the river contract of the Dyle catchment?

Even though there was an intention to have a water management plan in Wallonia, this has not materialised because of the traditional « *technico-administrative sectorisation* » of water management (Rosillon, 2001). In this « *sectorisation* », it is difficult to define a single DSS user who could have an integrated view of water issues in the Dyle catchment. This view is needed in order to define indicators and criteria for the MULINO_DSS. Moreover, the MULINO_DSS is not a multi-user tool. Thus, the participatory approach principle can only be implemented within a dialogue and consensus context before the results are entered into the DSS by a single user.

The coordination staff of the RC of the Walloon part of the Dyle catchment is part of the local network established as a first stage of the MULINO project in each case study. The RC of the Walloon part of the Dyle was signed in 1998. This means that the first four years of the contract (consisting in the implementation of concerted actions) have already been completed. The main actors for water resources in the Dyle catchment already discuss some issues together. The most difficult task, to provoke a dialogue between all the actors has, therefore, already been achieved in this case study. The work of the coordination staff leads to a consensus on feasible solutions such as, e.g., the location and the dimension of storm basins, by-pass of the river, awareness on agri-environmental measures and so on. This means that, first, the coordinator of the RC knows personally all the actors concerned with water resources in the catchment. Secondly, he is aware of all the issues for river management. Thirdly, because of the actions already implemented on the river and on the catchment for solving some issues, he has great knowledge about technical water management at the local level and knows about the establishment of a participatory approach. Finally, the coordinator and all the coordination staff were motivated to participate in the MULINO project and to exchange knowledge.

The RC has no legal power and cannot force actors to implement the actions they agree during the concertation phase. Because the funds allocated to the RC are small (maximum of 0.15 million euros for four years), the implementation of actions depends strongly on the participation of the actors. In spite of this absence of real power to implement important actions, however, the RC has, for the MULINO project, an interesting institutional position. To begin with, following its definition by the « circulaire ministérielle », it can be considered as the tool for the management of the « natural » part of the water resource cycle by harmonizing the uses along the river course. Furthermore, it has been established by the two ministries that have the most responsibility for water resource management (Fig. 3). Thus, it can assist those two ministries in finding coordinated solutions to water management issues of the "natural cycle" of water. Because some actors in the RC are also implicated in the « human cycle »—e.g. as drinking-water producers or commune authorities—the RC is well positioned to promote the coordination of local water issues.

The idea, therefore, is to deliver the MULINO_DSS to the coordinator of the RC who represents a « centralisation » or synthesis of the ideas proposed within the concertation between all the actors in the Walloon part of the Dyle catchment. The use of the MU-

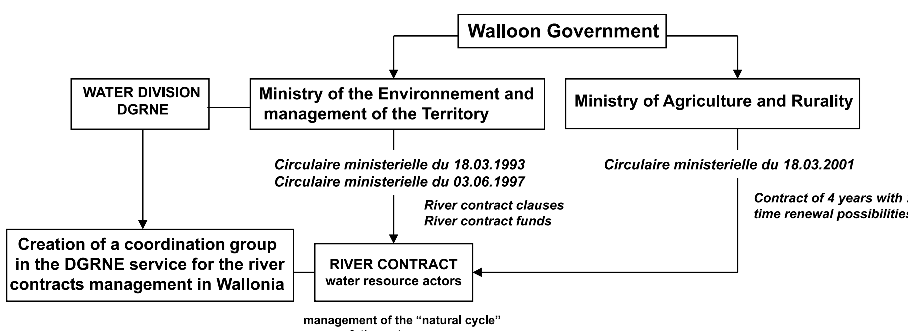

Fig. 3. The institutional position of the river contract in Wallonia (Belgium).

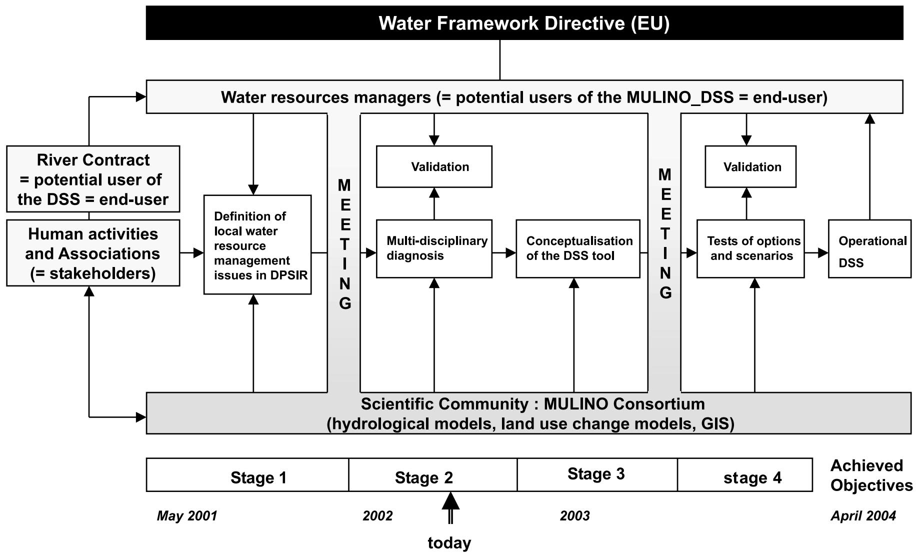

Fig. 4. The workplan of the MULINO project.

LINO_DSS could lead to (1) the understanding and acceptance of environmental decisions from the government, or (2) proposals of further management alternatives arising from a consensus. The ultimate objective is to support the RC in its participation in the decision making process concerning water resource management in order to provide a sustainable strategy at the catchment scale.

5. Discussion

The MULINO project aims to deliver a DSS that supports decision making in the integrated management of water resources at the catchment scale. The multicriteria analysis takes into account the weights input by a single user. However, the tool can support social interaction between stakeholders within the context of dialogue if the chosen weights for the criteria reflect a consensus between stakeholders. In the Dyle catchment, we have the opportunity to work with a RC which has created an existing dialogue between all the actors in the catchment. The well-functioning structure of the RC allows MULINO to (1) deal directly with integrated management alternatives, (2) develop an original concept to concretise the implementation of the participatory approach principle of the Water Framework Directive, (3) escape the need to develop more complex DSS software that could be capable to support social interactions, (4) contribute to sustainable decision-making.

Three current facts reinforce the decision of the MULINO project to work with the RC in the Belgian case study. First, more than 60% of the territory of Wallonia is covered by a RC. Secondly, the Ministry of agriculture and rural affairs has outlined its intention to continue the RC structure by a decree (Verhaegen, 2002). Thirdly, the existing RCs are adapting their spatial boundaries to coincide with the subcatchments of the hydrographical districts defined in Wallonia, so that the spatial limits of the RC could be coherent with the sub-scale of the implementation of the WFD.

In conclusion, working with a particular manager could have been a mistake because of the high level of fragmentation of the decision making structures concerning water resources in the case study presented here. The multi-sectoral and « historical » analysis of the decisional context proved to be crucial in the choice of an appropriate end-user within the local network.

The next steps for MULINO are to develop the DSS software and to run the hydrological models and the multicriteria analysis for alternative management options and future scenarios. The Fig. 4 gives an overview of the main components and phases of the MULINO project.

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